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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION FOR LETTERS PATENT

**SYSTEM AND METHOD FOR FABRICATING
SEMICONDUCTOR COMPONENTS USING
MOLD CAVITIES HAVING RUNNERS
CONFIGURED TO MINIMIZE VENTING**

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Field of the Invention

This invention relates generally to semiconductor packaging. More particularly, this invention relates to a system and to a method for fabricating semiconductor packages using mold cavities having runners configured to minimize venting.

Background of the Invention

Semiconductor packages typically include a semiconductor die encapsulated in a molded plastic body. The molded plastic body rigidifies and protects the die from the environment. Semiconductor packages also include a substrate, such as a leadframe, or a circuit board material, on which the die is mounted. The substrate includes conductors such as lead fingers for a leadframe, or conductive traces for a circuit board substrate which provide internal signal, power and ground paths through the package body to the die. The package also includes terminal contacts, such as metal leads, or solder balls, for making electrical connections from the outside to the package.

The molded plastic body can be formed using a transfer molding process. During this process a mold cavity is placed on the substrate and over the die, and a molding compound, such as an epoxy resin, is injected into the mold cavity. The molding compound can be injected on either side of the substrate to encapsulate the die and associated wire bonds.

A prior art transfer molding process is illustrated in Figure 1. In this example the substrate comprises a metal leadframe 10. Figure 1 illustrates only a portion of the leadframe 10, which includes multiple semiconductor dice 12 mounted in pairs across the width of the leadframe 10. The leadframe 10 is an elongated member configured to fabricate multiple semiconductor packages 14. Each package 14 includes

a molded plastic body 28 which encapsulates a die 12, and opposing surfaces on a portion of the leadframe 10.

The leadframe 10 includes openings 16A, 16B, 16C along longitudinal edges thereof, which facilitate handling by automated equipment such as conveyor tracks, magazines and loaders. The openings 16A, 16B, 16C also function to align the leadframe 10 on various process systems such as die attachers, wire bonders, molding systems, and singulation systems. The leadframe 10 also includes transverse thermal expansion slots 18 and leadfingers 20 that are wire bonded to bond pads (not shown) on the dice 12. The leadfingers 20 are connected by bus bars 22, and will subsequently be trimmed and formed into the terminal leads for the packages 14. Further, the leadframe 10 includes a molding slot 24 which facilitates the flow of a molding compound 26 during molding of the plastic bodies 28.

As illustrated by the flow arrows 30, during the molding process the molding compound 26 is injected across the width of the leadframe 10 from left to right in Figure 1. A system for performing the molding process includes mold cavities (not shown) clamped to the opposing surfaces of the leadframe 10. During the molding process, trapped air bubbles 36 in the molding compound 26 can be released to a dummy mold cavity (not shown) which forms dummy segments 38 on the opposing surfaces of the leadframe 10. However, some of the air is trapped at the corners of the mold cavities, proximate to the corners 32 of the molded plastic bodies 28. The trapped air requires that the molding system includes air vents 34 (indicated by dotted lines) in flow communication with the mold cavities proximate to the corners 32 of the molded plastic bodies 30.

One problem with the prior art molding system is that the air vents 34 will typically fill with molding compound 26 during normal production. At given intervals the air vents

34 must be cleaned, which requires that any molding compound 26, and also any cleaning compound in the air vents 34, be scrapped out and removed. In view of the large number of air vents 34 in a molding system and their small size, the
5 cleaning process takes time, and adversely affects the productivity of the molding system.

Another problem with the air vents 34 is the excess molding compound which forms in the air vents 34. This excess molding compound is sometimes referred to as mold
10 "flash". The flash fills the air vents 34 causing blockage and defective packages 14. In addition, small pieces of flash can break loose from the air vents and stick to the leadframe 10. The pieces of flash can cause shorting in the completed packages 14, and can also accumulate on various
15 process equipment, such as conveyor tracks, causing additional problems. Often times the flash pieces are charged such that they are attracted to metal surfaces.

The present invention is directed to a system and to a method for molding semiconductor components in which
20 additional runners are employed to channel the molding compound through corners of the mold cavities that must normally be vented. This eliminates a large number of air vents, and alleviates the cleaning and flash accumulation problems associated with the air vents.

Summary of the Invention

In accordance with the present invention, an improved system for fabricating semiconductor components, an improved method for fabricating semiconductor components, and improved
30 semiconductor components fabricated using the system and the method are provided.

In an illustrative embodiment, the system and the method are used to fabricate plastic semiconductor packages on a metal leadframe. The leadframe is configured to support

semiconductor dice in pairs two abreast for molding. In addition, the leadframe includes leadfingers wire bonded to the dice, and configured to form the internal and external leads for the packages.

5 The system includes an upper mold cavity plate having a plurality of upper mold cavities, and a lower mold cavity plate having a plurality of lower mold cavities. The upper mold cavity and the lower mold cavity are configured to engage opposing surfaces of the leadframe, and to mold the plastic packages onto the leadframe. In addition, each mold cavity plate includes corner runners configured to channel molding compound through the corners of the mold cavities, and into dummy cavities on opposing surfaces of the leadframe. The flow of molding compound through the corners prevents trapped air from accumulating in the corners. Each dummy cavity is in flow communication with a single air vent, and any trapped air in the molding compound is channeled through the dummy mold cavities and into the air vents. The runners eliminate the corner air vents of the prior art molding system such that there are fewer air vents to clean and less flash particles are produced.

15 The method includes the step of providing the upper mold cavity and the lower mold cavity with the mold cavities, the runners, the dummy cavities and the air vents. The method also includes the steps of injecting the molding compound into the mold cavities, and directing the molding compound proximate to the corners of the mold cavities using the runners. In addition, the method includes the step of directing trapped air through the runners into the dummy mold cavities, and then out the air vents.

25 Each semiconductor package includes a semiconductor die, and upper and lower body segments encapsulating the die and a portion of the leadframe. Prior to singulation of the packages, the leadframe includes upper dummy segments and

lower dummy segments on upper and lower surfaces thereof proximate to an edge of the leadframe. The leadframe also includes a connecting dummy segment on the lower surface thereof between adjacent pairs of packages. In addition, the leadframe includes second dummy segments on the lower surface thereof connected to the lower dummy segments.

Brief Description of the Drawings

Figure 1 is a schematic cross sectional view illustrating a prior art method for molding a semiconductor package using multiple vents located proximate to the corners of the package;

Figures 2A-2D are schematic cross sectional views illustrating a system constructed in accordance with the invention, and steps in a method for fabricating semiconductor packages in accordance with the invention;

Figure 3A is a bottom view of an upper mold cavity plate of the system taken along line 3A-3A of Figure 2A;

Figure 3B is a side elevation view of the upper mold cavity plate;

Figure 3C is an enlarged view of a portion of the upper mold cavity plate taken along dotted segment 3C of Figure 3A illustrating upper mold cavities on the upper mold cavity plate;

Figure 3D is a side elevation view of the upper mold cavities;

Figure 3E is an enlarged view of a portion of the upper mold cavity plate taken along dotted segment 3E of Figure 3A illustrating a dummy mold cavity on the upper mold cavity plate;

Figure 3F is a side elevation view of the dummy mold cavity;

Figure 3G is an end view of the dummy mold cavity;

Figure 4A is a plan view of a lower mold cavity plate of the system taken along line 4A-4A of Figure 2A;

Figure 4B is a side elevation view of the lower mold cavity plate;

5 Figure 4C is an enlarged view of a portion of the lower mold cavity plate taken along dotted segment 4C of Figure 4A illustrating lower mold cavities on the lower mold cavity plate;

10 Figure 4D is a side elevation view of a lower mold cavity;

Figure 4E is an enlarged view of a portion of the lower mold cavity plate taken along dotted segment 4E of Figure 4C illustrating a connecting dummy cavity on the lower mold cavity plate;

15 Figure 4F is a side elevation view of the connecting dummy cavity;

Figure 4G is an end elevation view of the connecting dummy cavity;

20 Figure 4H is an enlarged view of a portion of the lower mold cavity plate taken along dotted segment 4H of Figure 4C illustrating a dummy mold cavity on the lower mold cavity plate;

Figure 4I is an end elevation view of the dummy mold cavity;

25 Figure 4J is a side elevation view of the dummy mold cavity;

Figure 5 is an enlarged plan view taken along line 5-5 of Figure 2B illustrating a leadframe configured for constructing packages in accordance with the invention;

30 Figure 6 is a cross sectional view taken along section line 6-6 of Figure 2C illustrating a flow of a molding compound on an upper surface of the leadframe during a molding step;

Figure 7A is a plan view taken along line 7A-7A of Figure 2D illustrating semiconductor packages on the leadframe constructed using the system and method of the invention; and

5 Figure 7B is a side elevation view of the semiconductor packages on the leadframe.

Detailed Description of the Preferred Embodiments

Referring to Figures 2A-2D, a system 40 for fabricating semiconductor components, and steps in a method for fabricating the semiconductor components using the system 40 are illustrated. In the illustrative embodiment, the components comprise semiconductor packages 52 (Figure 2D) having a TSOP (thin small outline package) configuration. However, it is to be understood that the system 40, and the method, can be used to fabricate other types of semiconductor components, such as chip scale packages, BGA devices, multi chip modules and other types of plastic packages (e.g., DIPs, SIPs etc.).

20 Referring to Figure 2A, the system 40 includes a transfer molding apparatus 58. One suitable transfer molding apparatus 58 is manufactured by ASAHI Engineering Company of Japan and is designated a "COSMO" model.

The system 40 also includes an upper mold cavity plate 42U, and a lower mold cavity plate 42L. The upper mold cavity plate 42U and the lower mold cavity plate 42L are movable by the transfer molding apparatus 58 between an open position (Figure 2A), and a closed position (Figure 2C). However, as is apparent the "upper" and "lower" terminology is for illustrative purposes, and would change according to the orientation of the system 40. Accordingly, the claims to follow refer generically to "a first mold cavity plate" (i.e., upper mold cavity plate 42U) and to "a second mold cavity plate" (i.e., lower mold cavity plate 42L).

Referring to Figure 2B, for performing a molding step of the method, a leadframe 46 is placed between the upper mold cavity plate 42U and the lower mold cavity plate 42L. The transfer molding apparatus 58 can include suitable mechanisms (not shown) for placing and aligning the leadframe 46 between the mold cavity plates 42U, 42L. However, prior to the molding step, a plurality of semiconductor dice 56 (Figure 5) are attached to the leadframe 46. The leadframe 46 includes an upper surface 47U on which the dice are mounted, and a lower surface 47L. In addition, as shown in Figure 5, the leadframe 46 includes a plurality of lead fingers 60, and the dice 56 are wire bonded to the lead fingers 60. The leadframe 46 can also include a plurality of mounting paddles (not shown) for supporting the dice 56.

As shown in Figure 5, the lead fingers 60 are initially connected by a bus bar 62, but following a trim and form step, will become the external leads for the semiconductor packages 52. As also shown in Figure 5, the leadframe 46 includes handling openings 68A, 68B, 68C, and thermal expansion slots 66 that function substantially as previously described. In addition, the leadframe 46 includes mold inlet openings 64, connecting segment openings 70, and dummy segment openings 72 configured to facilitate the flow of the molding compound 50 and the formation of the molded features on the leadframe 46.

Referring to Figure 2C, during the molding step, the upper mold cavity plate 42U and the lower mold cavity plate 42L are clamped by the transfer molding apparatus 58 to the upper surface 47U and the lower surface 47L of the leadframe 46. As also shown in Figure 2C, the system 40 includes a molding compound source 48 configured to inject a molding compound 50 (Figure 6) under pressure between the upper mold cavity plate 42U and the lower mold cavity plate 42L. The flow of the molding compound 50 (Figure 6) during the molding

step will be more fully explained as the description proceeds. Also during the molding step, air is vented from the upper mold cavity plate 42U and the lower mold cavity plate 42L through upper air vents 84U, and lower air vents 84L as indicated by air flow arrow 54. Although there are a plurality of air vents 84U, 84L, a single upper air vent 84U and a single lower air vent 84L is associated with each pair of packages 52 on the leadframe 46.

Referring to Figure 2D, following the molding step the leadframe 46 includes a plurality of semiconductor packages 52. The leadframe 46 with the semiconductor packages 52 thereon is also shown in Figures 7A and 7B. Each semiconductor package 52 includes an upper body segment 74 and a lower body segment 76, having matching thicknesses and peripheral outlines. However, it is to be understood that the invention can also be practiced to form a molded body segment on only one side of a semiconductor component, or to form a component having asymmetrical molded body segments.

As also shown in Figure 2D, the leadframe 46 includes upper dummy segments 80 and lower dummy segments 82 located proximate to a right lateral edge 98 of the leadframe 46. In addition, the leadframe 46 includes connecting dummy segments 78 located between adjacent semiconductor packages 52. The structure and function of the dummy segments 78, 80, 82 will be more fully explained as the description proceeds.

Referring to Figures 3A-3D, the upper mold cavity plate 42U is illustrated. The upper mold cavity plate 42U is preferably machined out of a single block of a metal, such as stainless steel. As shown in Figure 3A, the upper mold cavity plate 42U has a generally rectangular peripheral shape which corresponds to, but is slightly larger than the rectangular peripheral shape of the leadframe 46.

As also shown in Figure 3A, the upper mold cavity plate 42U includes a plurality of upper mold cavities 86U, which

are arranged in pairs corresponding to the locations of the semiconductor dice 56 (Figure 5) on the leadframe 46. The upper mold cavities 86U are configured to mold the upper body segments 74 (Figure 2D) of the packages 52 (Figure 2D). The upper mold cavity plate 42U also includes upper dummy mold cavities 102U configured to mold the upper dummy segments 80 (Figure 2D) on the leadframe 46.

As shown in Figure 3B, the upper mold cavity plate 42U also includes handling recesses 88U on opposing sides thereof. In addition the upper mold cavity plate 42U includes stepped surfaces 90U on opposing ends thereof.

As shown in Figure 3C, the upper mold cavity plate 42U also includes openings 92U in the upper mold cavities 86U configured to receive knockout pins for pushing the semiconductor packages 52 (Figure 2D) out of the upper mold cavities 86U. In addition, the upper mold cavity plate 42U includes through holed openings 94U configured to for use with associated ejector pins for ejecting the leadframe 46.

As also shown in Figure 3C, the upper mold cavity plate 42U includes inlet runners 96U configured to receive the molding compound 50 (Figure 6) from the molding compound source 48 (Figure 2C), and to direct the molding compound 50 into the upper mold cavities 86U. In addition, the upper mold cavity plate 42U includes connecting runners 100U configured to direct the molding compound 50 between adjacent pairs of upper mold cavities 86U. Further, the upper mold cavity plate 42U includes corner runners 106U configured to direct the molding compound 50 into the corners 108U of the upper mold cavities 86U. As will be further explained, the corner runners 106U prevent air from being trapped in the corners 108U of the upper mold cavities 86U, and allow the air vents 34 (Figure 1) of the prior art system to be eliminated. In addition, the corner runners 106 improve the

construction of the packages 52 because the corners thereof do not include trapped air.

As shown in Figure 3C, the upper mold cavity plate 42U also includes dummy runners 110U configured to direct the molding compound 50 from the upper mold cavities 86U into the dummy cavities 102U. In addition, the upper mold cavity plate 42U includes the upper air vents 84U configured to vent air from the dummy mold cavities 102U to atmosphere. Each pair of upper mold cavities 86U has a single upper air vent 84U associated therewith. However, all of the air vents 84U are in flow communication and vent to atmosphere.

During the molding step, the inlet runners 96U, the corner runners 106U, the connecting runners 100U, and the dummy runners 110U, in combination with the upper surface 47U (Figure 2B) of the leadframe 46, form closed conduits for channeling the flow of the molding compound 50 over the upper surface 47U of the leadframe 46.

Still referring to Figure 3C, the upper mold cavities 86U include peripheral lips 104U which are also known as "clamping surfaces" which are configured to engage the upper surface 47U of the lead frame 46. The peripheral lips 104L are the highest surfaces on the upper mold cavity plate 42U and sealingly engage the upper surface 47U of the lead frame 46 for forming the upper body segments 74 of the packages 52. In addition, the peripheral lips 104U space the runners 96U, 106U, 100U, 110U from the upper surface 47U of the leadframe 46 such that the molding compound 50 can flow between the runners 96U, 106U, 100U, 110U and the upper surface 47U of the leadframe 46.

One method for fabricating the peripheral lips 104L is to EDM (electric discharge machine) the cross hatched area 112U which surrounds the peripheral lips 104L to a selected depth. By way of example, this cross hatched area 112U can be EDMed to a depth measured from the surfaces of the

peripheral lips 104L of about 1.01 to 1.78 mm. Similarly, the inlet runners 96U, the corner runners 106U, the connecting runners 100U, the dummy runners 110U and the air vents 84U can be EDMed to selected depths with respect to the surfaces of the peripheral lips 104L. By way of example, the depth of the inlet runners 96U, the connecting runners 100U and the dummy runners 110U can be about 0.005 - 0.008 mm. The depth of the corner runners 106U and the air vents 84U can be about 0.025 mm. In Figure 3C, areas that have the same depth are cross hatched with the same section lines.

Figure 3D illustrates the depth of the upper mold cavities 86U which is about 10 times greater than the depths of the runners 96U, 106U, 100U, 110U listed above. Accordingly, for simplicity Figure 3D does not illustrate the depth of the runners 96U, 106U, 100U, 110U or the height of the peripheral lips 104U relative to the runners. By way of example, the upper mold cavities 86U can be EDMed to a depth of about 0.445 mm. In addition, the upper mold cavities 86U can have a length of about 18.40 mm and a width of about 14.000 mm. The inlet runners 96U can have a width of about 5.00 mm. The corner runners 106U can have a length of about 4.00 mm, and a width of about 0.8 mm. The peripheral lips 104U can have a width of about 0.8 mm.

Referring to Figures 3E-3G, a dummy mold cavity 102U and associated air vent 84U are illustrated. The dummy mold cavities 102U can have a depth of about 0.445 mm, a length of about 7.20 mm and a width of about 1.30 mm. However, as is apparent, all of the dimensions given above are merely exemplary, and can be adjusted as required by the skilled artisan.

Referring to Figures 4A-4I, the lower mold cavity plate 42L is shown. The lower mold cavity plate 42L is constructed substantially in a mirror image of the upper mold cavity plate 42U. In addition, the lower mold cavity plate 42L has

the same size and shape as the upper mold cavity plate 42U includes the same stepped surfaces 90L as opposing ends. In addition, the lower mold cavity plate 42L includes lower mold cavities 86L having peripheral lips 104L (Figure 4C) configured to sealingly engage the lower surface 47L of the leadframe 46. The lower mold cavities 86L and the upper mold cavities 86U form enclosed spaces which substantially determine the size and shape of the semiconductor packages 52 (Figure 2D). The peripheral lips 104U of the lower mold cavities 86L are defined by EDMed surface 112L. The lower mold cavity plate 42L also includes openings 92L for knock out pins.

The lower mold cavity plate 42L also includes inlet runners 96L, corner runners 106L, connecting runners 106L, dummy runners 110L, dummy mold cavities 102L and air vents 84L. These elements are constructed substantially as mirror images of the equivalent elements contained on the upper mold cavity plate 42U. However, there are some differences between these elements. Specifically, as shown in Figure 4C, the inlet runners 96L include faceted surfaces.

In addition, as shown in Figures 4E-4G, the connecting runners 100L include a connecting dummy cavity 114L, configured to form the connecting dummy segment 78 (Figure 2D) between the packages 52. As shown in Figure 4E, the connecting dummy cavity 114L is generally circular in shape with faceted surrounding surfaces. Further, as shown in Figures 4H-4I, the dummy runners 110L include a second dummy cavity 116L configured to form a second lower dummy segment 118 (Figure 2D) on the leadframe 46. As shown in Figure 4H, the second dummy cavity 116L is generally circular in shape with faceted surrounding surfaces.

Referring to Figure 6, the flow of the molding compound 50 over the upper surface 47U of the leadframe 46 during the molding step is illustrated. As indicated by flow arrows

120, the molding compound 50 enters the inlet runners 96U and is directed into the upper mold cavities 86U (Figure 3C). In general, the flow of the molding compound 50 is from left to right in Figure 6, from the left lateral edge 99 of the leadframe 46 towards the right lateral edge 98 of the leadframe 46. However, as is apparent the "right" and "left" terminology is for illustrative purposes, and would change according to the orientation of the leadframe 46. Accordingly the claims to follow refer generically to a "first edge" (i.e., left lateral edge 99) and to a "second edge" (i.e., right lateral edge 98).

The corner runners 106U also direct the molding compound 50 proximate to the corners 108U (Figure 3C) of the upper mold cavities 86U such that the corners 124 of the packages 52 do not include voids and trapped air 120. Each corner 124 includes orthogonal surfaces such that the corner runners 106U direct the flow of the molding compound 50 through the corner 124 in a direction generally perpendicular to one corner surface and generally parallel to the other corner surface. With the corner runners 106U directing the flow of the molding compound through the corners 124, there is no need to vent the corners 108U (Figure 3C) of the upper mold cavities 86U.

In the illustrative embodiment the corner runners 106 are configured to initially direct the molding compound 50 along outside edges of the upper mold cavities 86U on the left lateral edge 99 of the leadframe 46 in a flow direction generally perpendicular to the flow of the molding compound through the inlet runners 96U. In addition, the corner runners 106U are configured to turn the flow direction of the molding compound approximately 90° such that the molding compound 50 enters the corners 108U of the upper mold cavities 86U on the left lateral edge 99 of the leadframe 46

in a flow direction that is generally parallel to the flow direction through the inlet runners 96U.

The molding compound 50 is also directed through the connecting runners 100U into the adjacent mold cavities 86U.

5 The flow direction through the connecting runners 100U is generally parallel to the flow direction through the inlet runners 96U. The corner runners 106U are configured to turn the molding compound 50 exiting the upper mold cavities 86U on the left lateral edge 99 of the leadframe 46 approximately
10 90° and towards the connecting runners 100U, then 180° and away from the connecting runners 100U.

The molding compound 50 is also directed through the dummy runners 110U and into the dummy mold cavity 102U. Any trapped air 122 is also directed into the dummy mold cavity
15 102U and is vented through the air vent 84U to atmosphere. The corner runners 106U are configured to turn the molding compound 50 exiting the upper mold cavities 86U on the right lateral edge 99 of the leadframe 46 approximately 90°, and to direct the molding compound towards the dummy runners 110U.
20 The corner runners 106U then turn the flow of the molding compound approximately 90° in a direction generally parallel to the flow direction through the dummy runners 110U and the dummy mold cavities 102U.

The flow of the molding compound over the lower surface
25 47L (Figure 2C) of the leadframe 46 is substantially the same as described above, except the connecting dummy segment 78 (Figure 2C) and the second lower dummy segment 118 (Figure 2C) are also formed and function as package to package runners.

30 Thus the invention provides a system and a method for fabricating semiconductor components, and improved semiconductor components fabricated using the system and the method. While the invention has been described with reference to certain preferred embodiments, as will be

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